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(54) **AP-LOCAL DYNAMIC SWITCHING**

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(58) **Field of Classification Search**
None
See application file for complete search history.

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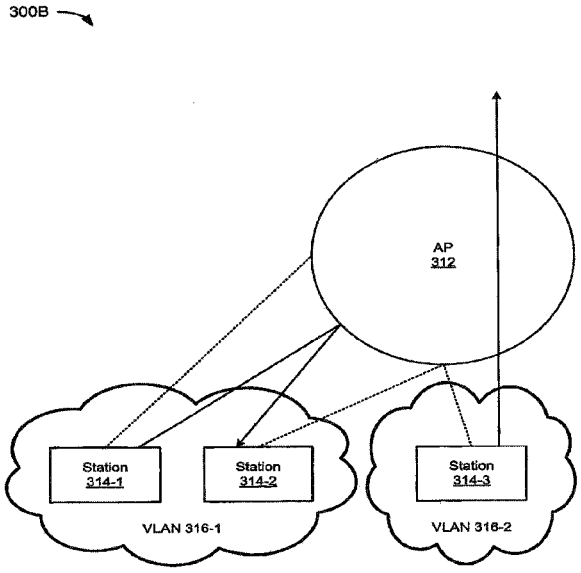
(57) **ABSTRACT**

A technique for implementing AP-local dynamic switching involves Layer 2 switching. This may be accomplished by providing data associated with wireless stations to an AP sufficient to enable the AP to determine whether traffic from a particular wireless station should be locally switched. Alternatively, the wireless station may be able to determine whether to locally switch traffic based upon the traffic itself. For example, it may be desirable to AP-locally switch voice traffic to avoid latency, which is particularly detrimental to voice transmissions such as voice-over-IP. Traffic that is not to be switched locally is Layer 2 tunneled upstream.

20 Claims, 8 Drawing Sheets



Related U.S. Application Data

continuation of application No. 14/996,088, filed on Jan. 14, 2016, now Pat. No. 9,838,942, which is a continuation of application No. 12/304,100, filed as application No. PCT/US2007/013757 on Jun. 11, 2007, now Pat. No. 9,258,702, which is a continuation-in-part of application No. 11/801,964, filed on May 11, 2007, now Pat. No. 8,818,322.

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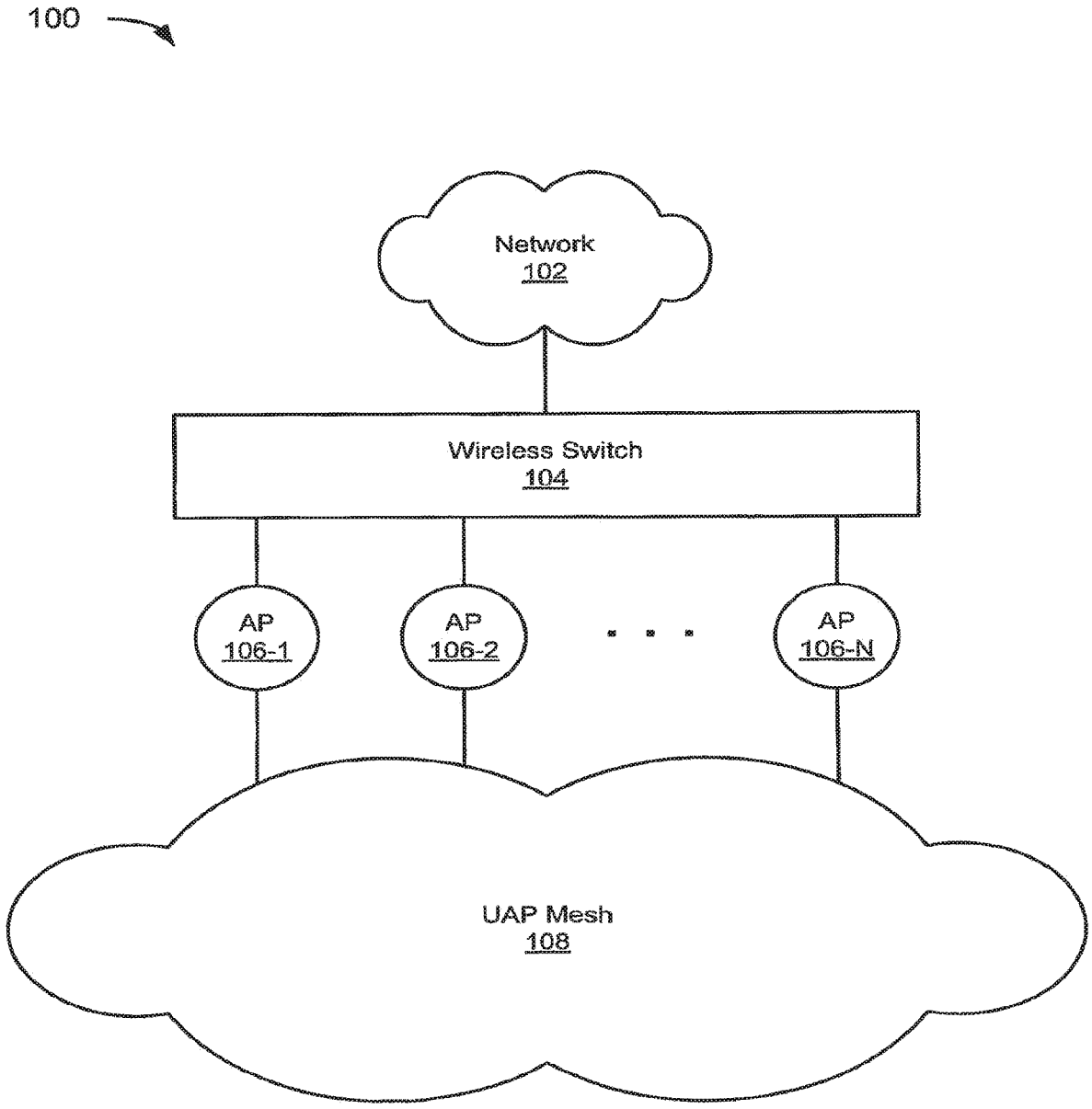
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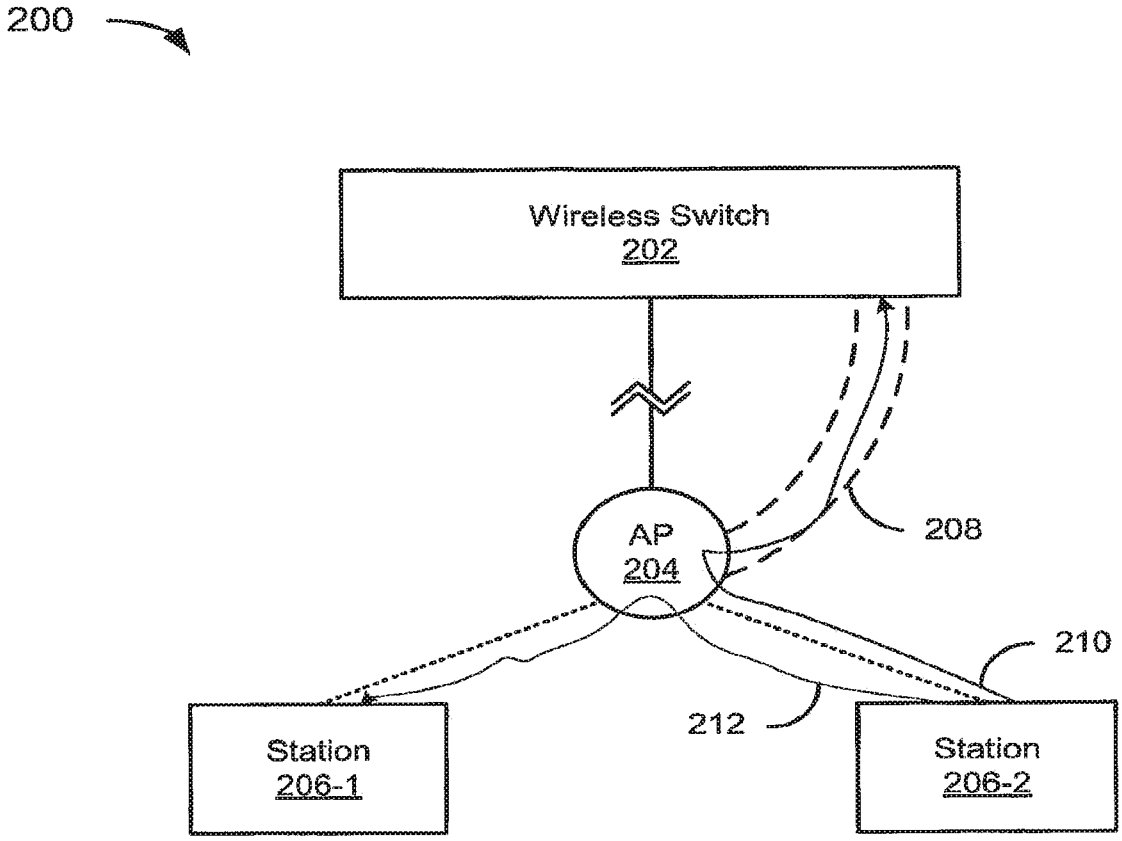
102
Wireless Switch
104
AP
106-1
AP
106-2
AP
106-N
UAP Mesh
108

FIG. 1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Wireless Switch
202
AP
204
208
210
212
Station
206-1
Station
206-2

FIG. 2

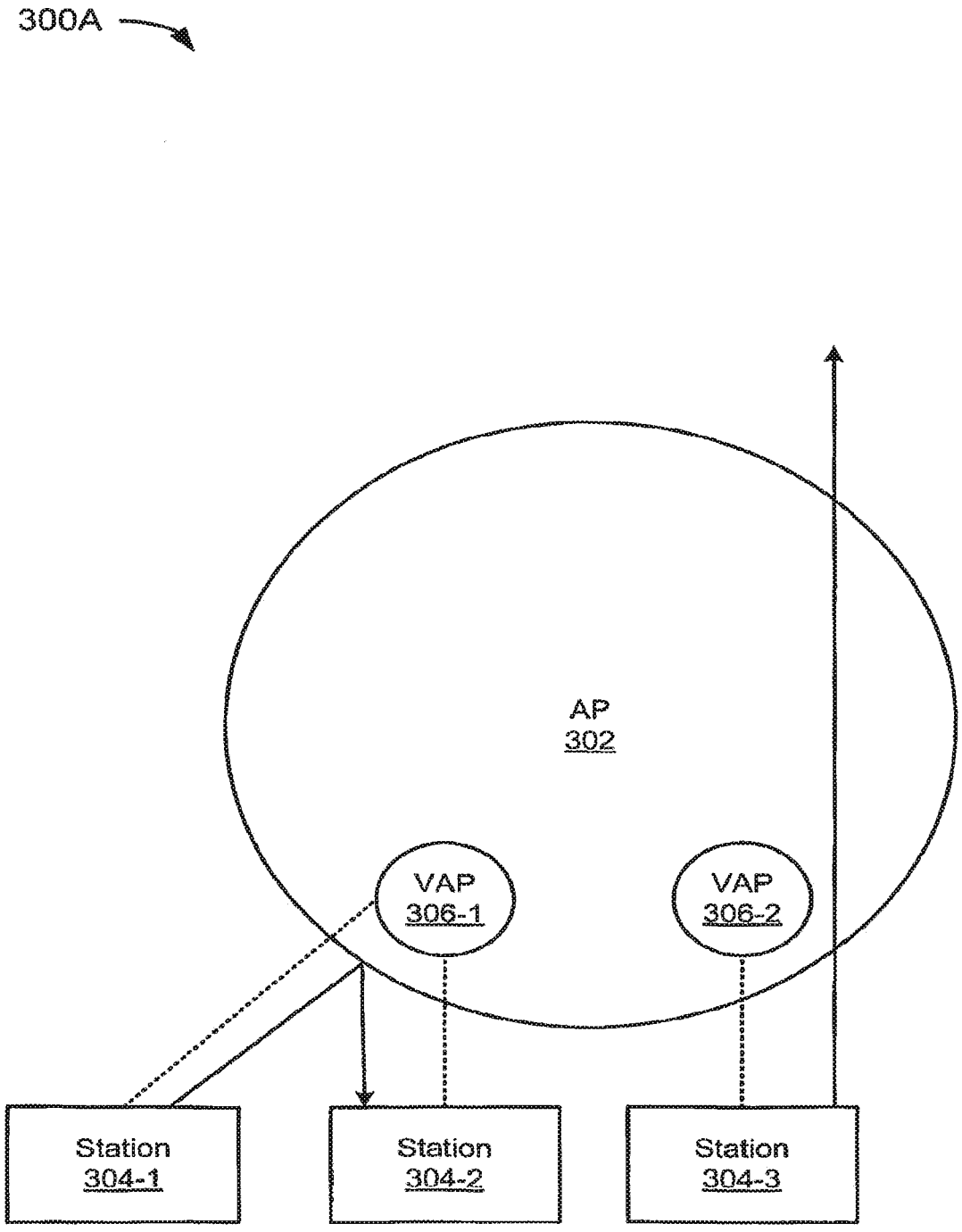

300A
AP
302
VAP
306-1
VAP
306-2
Station
304-1
Station
304-2
Station
304-3

FIG. 3A

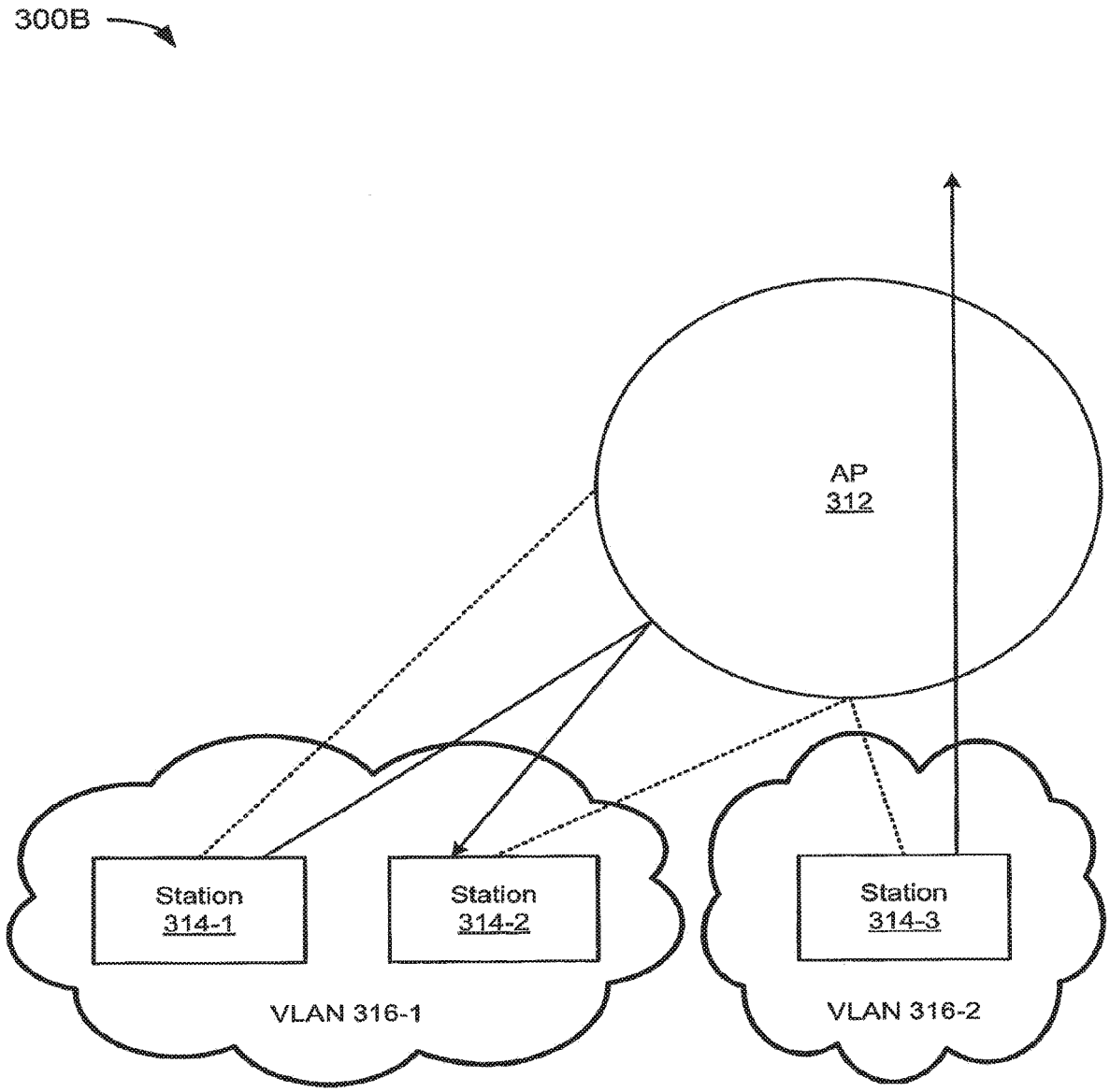

300B
AP
312
Station
314-1
Station
314-2
Station
314-3
VLAN 316-1
VLAN 316-2

FIG. 3B

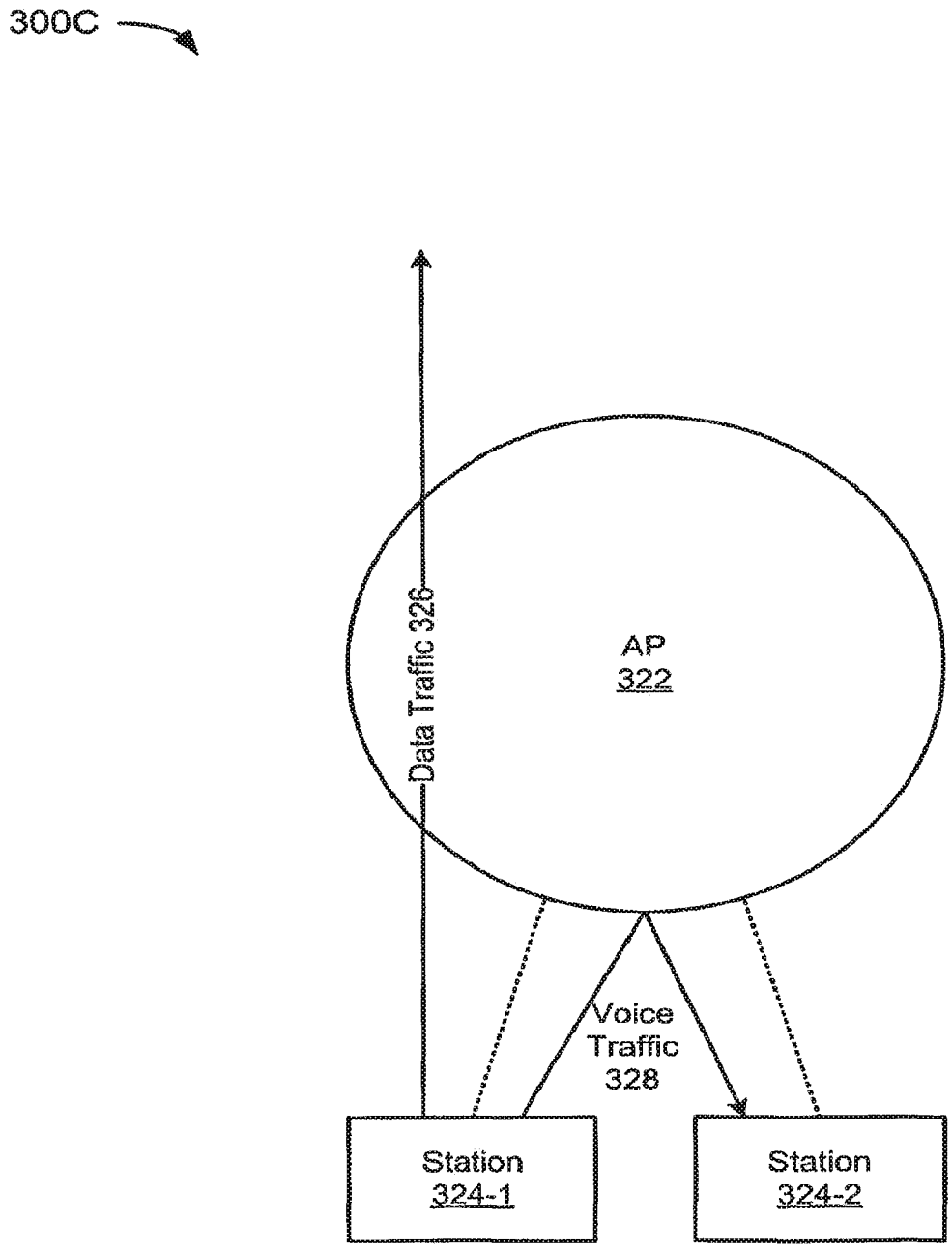

300C
Data Traffic 326
AP
322
Voice
Traffic
328
Station
324-1
Station
324-2

FIG. 3C

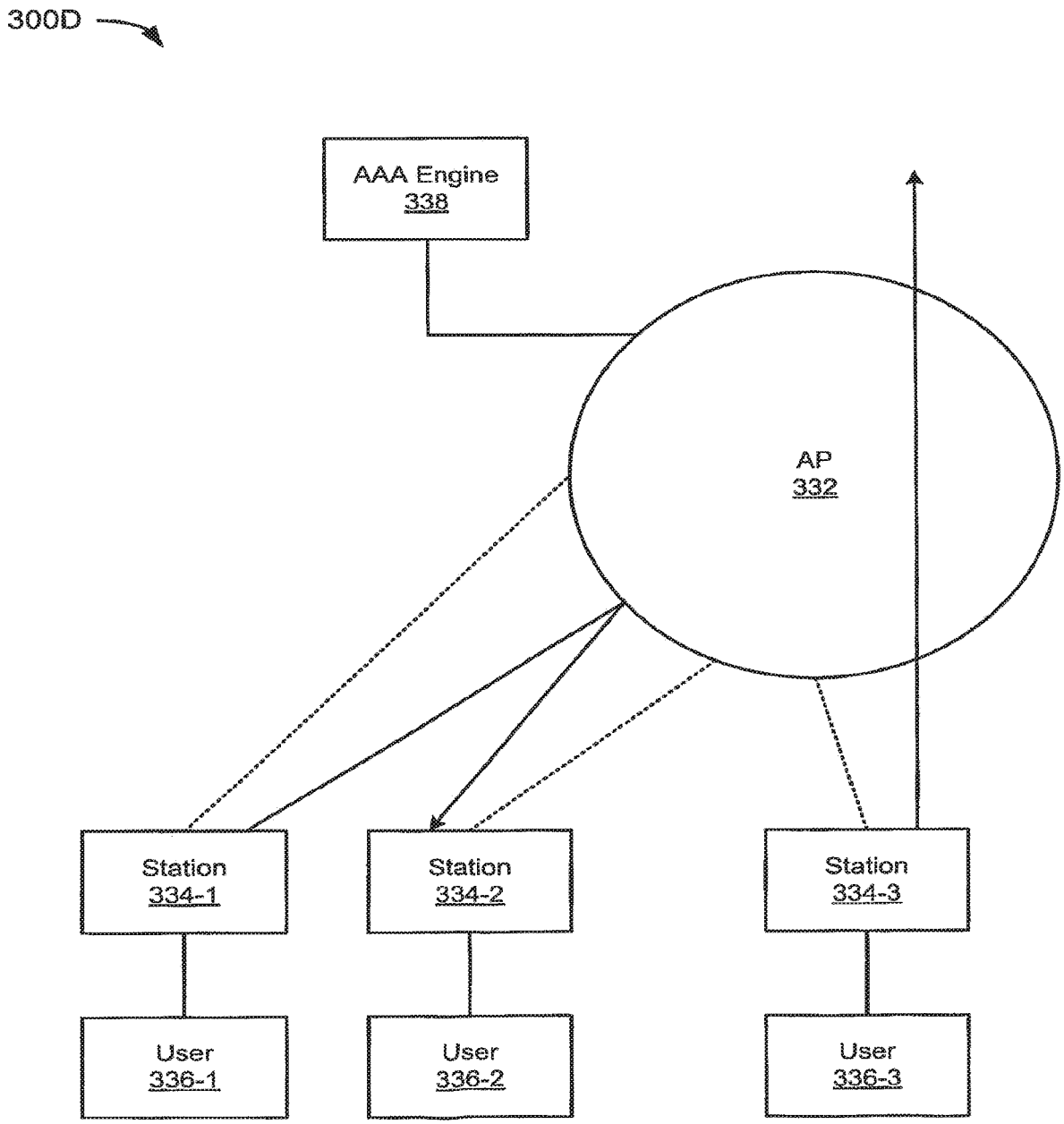
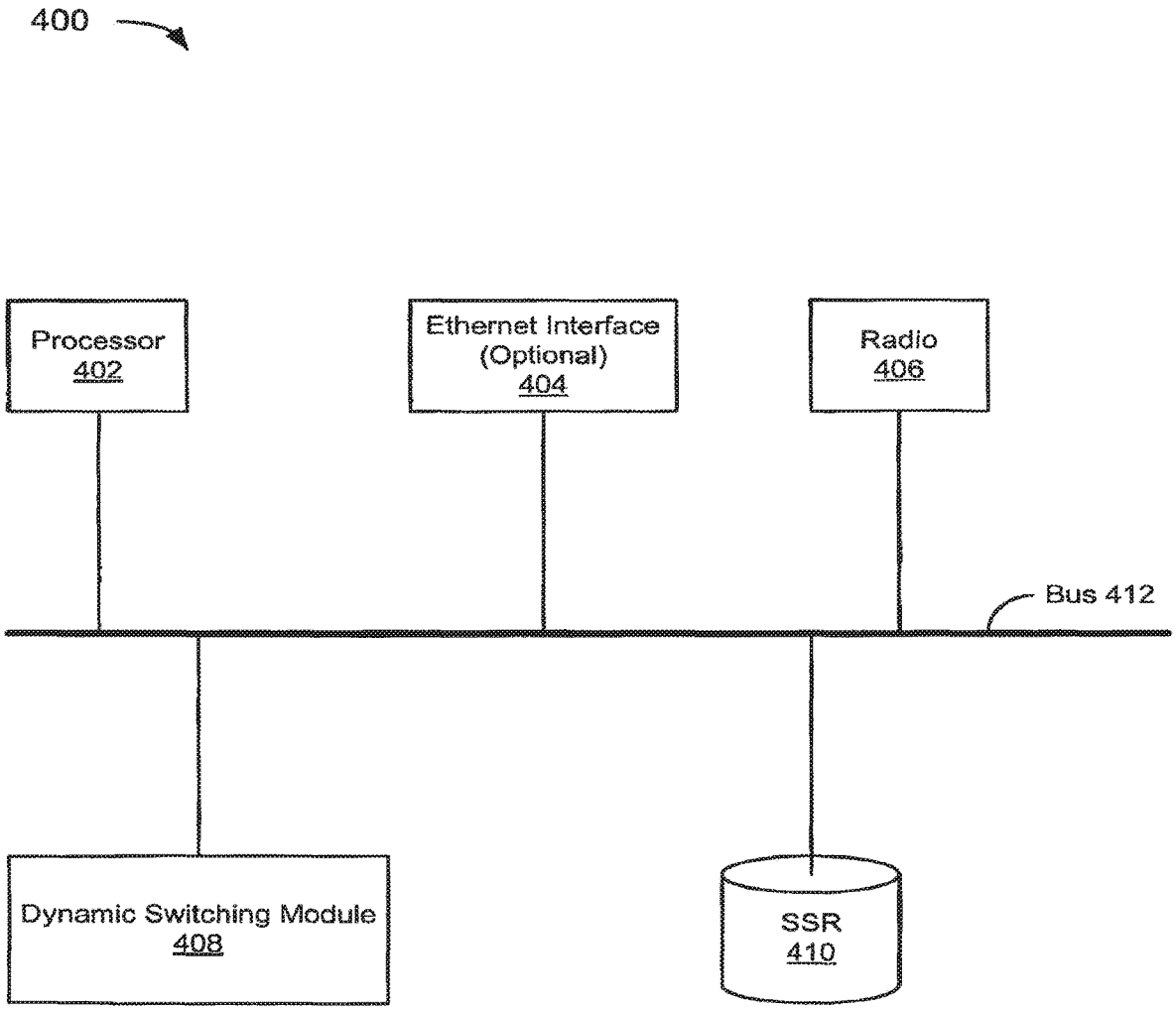

300D
AAA Engine
338
AP
332
Station
334-1
Station
334-2
Station
334-3
User
336-1
User
336-2
User
336-3

FIG. 3D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Processor
402
Ethernet Interface
(Optional)
404
Radio
406
Bus 412
Dynamic Switching Module
408
SSR
410

FIG. 4

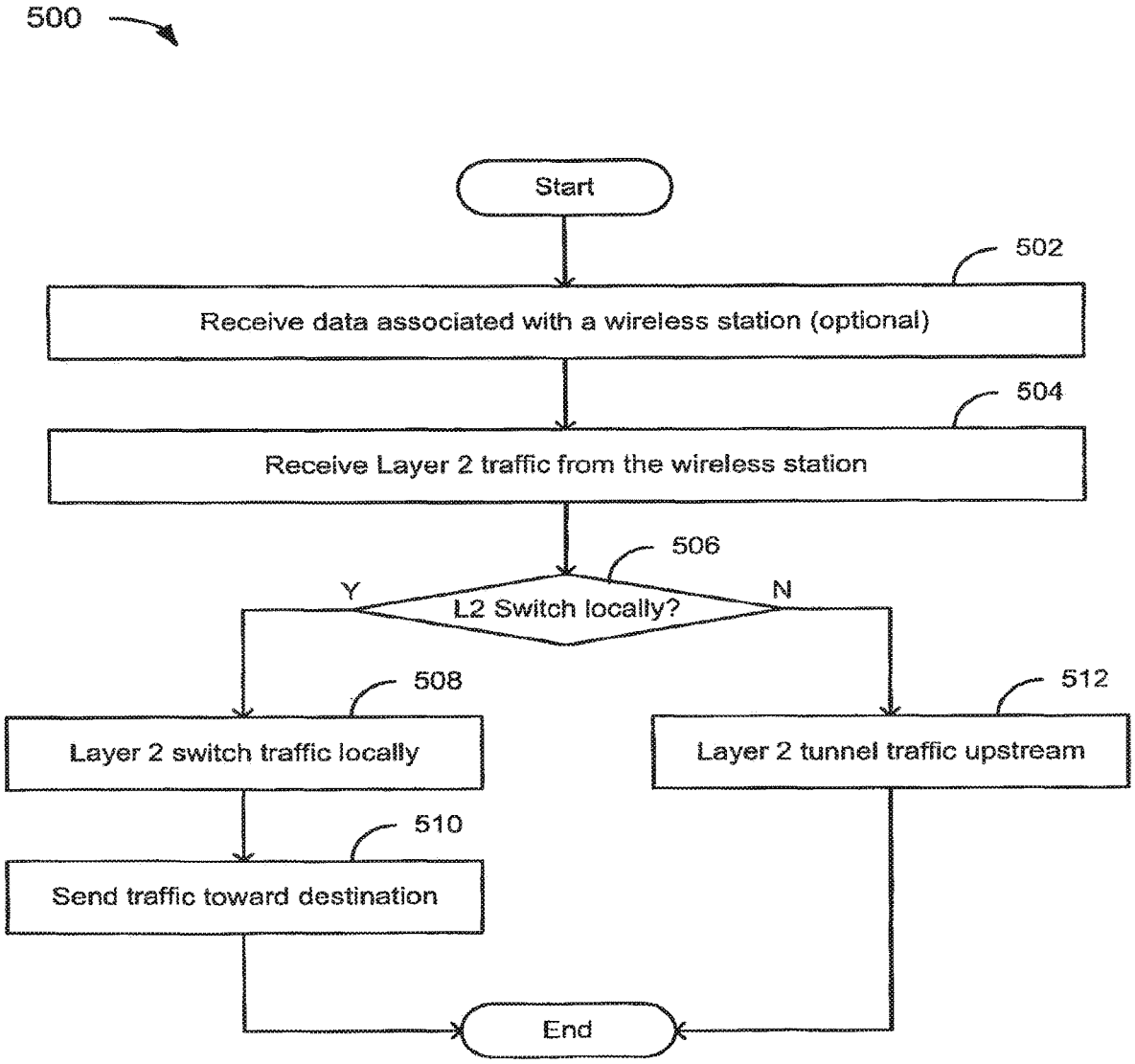
500
Start
502
Receive data associated with a wireless station (optional)
504
Receive Layer 2 traffic from the wireless station
506
L2 Switch locally?
Y
N
508
Layer 2 switch traffic locally
510
Send traffic toward destination
512
Layer 2 tunnel traffic upstream
End

FIG. 5

AP-LOCAL DYNAMIC SWITCHING

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This patent application is a Continuation of U.S. patent application Ser. No. 15/803,208, entitled "AP-LOCAL DYNAMIC SWITCHING," filed Nov. 3, 2017 (now U.S. Pat. No. 10,327,202), which is a Continuation of U.S. patent application Ser. No. 14/996,088, entitled "AP-LOCAL DYNAMIC SWITCHING," filed Jan. 14, 2016 (now U.S. Pat. No. 9,838,942), which is a Continuation of and claims priority to and the benefit of U.S. patent application Ser. No. 12/304,100, titled "AP-LOCAL DYNAMIC SWITCHING," filed Aug. 6, 2010 (now U.S. Pat. No. 9,258,702), which is the National Stage of International Patent Application Number PCT/US2007/013757, filed Jun. 11, 2007, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/812,403, filed Jun. 9, 2006, and which is a Continuation-in-Part of U.S. patent application Ser. No. 11/801,964, filed May 11, 2007 (now U.S. Pat. No. 8,818,322), the disclosures of each of which are hereby incorporated by reference in their entireties.

BACKGROUND

An access point (AP) is a device used by wireless clients to connect to a network. An AP functions as a standalone entity in some implementations and auctions in cooperation with distribution hardware in other implementations. Distribution hardware may include a wireless switch used to manage APs and provide network-connectivity to wireless clients. A wireless domain may refer to a group of wireless switches that are configured to exchange relevant information, and using this information make informed decisions. A known device is a station (e.g., a wireless AP or client device) that is part of a network wireless installation.

Trapeze Networks, Inc. (Trapeze), uses a MOBILITY POINT® (MP®) APs in a MOBILITY DOMAIN™ wireless domain. An MP® AP is coupled to a MOBILITY EXCHANGE® (MX®) wireless switch. Trapeze uses MOBILITY DOMAIN™ to refer to a collection of MX® switches. This collection of MX® switches shares RF environment and station association information. This information is used by the MX® switches to support features including by way of example but not limitation roaming, auto channel selection, rogue AP detection, intrusion detection and/or the launching of countermeasures. Some additional details regarding the Trapeze-specific implementation is provided by way of example but not limitation, including novel features that are discussed later in this application, in the provisional application to which this application claims priority.

In a typical implementation, switching is performed, as may be expected, by the switch. However, it is also possible to perform native switching at an AP. It is a non-trivial problem to coordinate AP-local switching with centralized control. It is also a non-trivial problem to provide hybrid switching, that is, AP-local switching combined with switching at the switch.

These are but a subset of the problems and issues associated with wireless access point authentication, and are intended to characterize weaknesses in the prior art by way of example. The foregoing examples of the related art and limitations related therewith are intended to be illustrative and not exclusive. Other limitations of the related art will

become apparent to those of skill in the art upon a reading of the specification and a study of the drawings.

SUMMARY

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

A technique for implementing AP-local dynamic switching involves Layer 2 switching. This may be accomplished by providing data associated with wireless stations to an AP sufficient to enable the AP to determine whether traffic from a particular wireless station should be locally switched. Alternatively, the wireless station may be able to determine whether to locally switch traffic based upon the traffic itself. For example, it may be desirable to AP-locally switch voice traffic to avoid latency, which is particularly detrimental to voice transmissions such as voice-over-IP. Traffic that is not to be switched locally is Layer 2 tunneled upstream.

The proposed system can offer, among other advantages, efficient utilization of bandwidth, reduced latency, network efficiency, reliability. This and other advantages of the techniques described herein will become apparent to those skilled in the art upon a reading of the following descriptions and a study of the several figures of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the claimed subject matter are illustrated in the figures. However, the embodiments and figures are illustrative rather than limiting; they provide examples of the claimed subject matter.

FIG. **1** depicts an example of a system including an untethered access point (UAP) mesh.

FIG. **2** depicts an example of a AP-local dynamic switching system.

FIGS. **3**A to **3**D depict by way of example but not limitation various factors that could be considered when determining whether to switch locally at an AP or at a switch.

FIG. **4** depicts an example of an AP capable of AP-local dynamic switching.

FIG. **5** depicts a flowchart of an example of a method for AP-local dynamic switching.

DETAILED DESCRIPTION

In the following description, several specific details are presented to provide a thorough understanding of embodiments of the claimed subject matter. One skilled in the relevant art will recognize, however, that the claimed subject matter can be practiced without one or more of the specific details, or in combination with other components, etc. In other instances, well-known implementations or operations are not shown or described in detail to avoid obscuring aspects of various embodiments, of the claimed subject matter.

FIG. **1** depicts an example of a system **100** including an untethered access point (UAP) mesh. In the example of FIG. **1**, the system **100** includes a network **102**, a wireless switch **104**, one or more APs **106-1** to **106**-N (referred to collectively as APs **106**), and a UAP mesh **108**. It should be noted that while an overlay switching model is in some ways replaced by the techniques described herein, it may be

desirable to prevent the implementation of local switching from removing any functionality of the overlay model.

An overlay switch model includes APs that tunnel to an upstream switch (e.g., an MX®), allowing the switch to perform complex policy and forwarding decisions locally. Centralizing switching to an upstream switch has allowed AP switching code to remain relatively simple (supporting the Thin-AP model). The AP at least knows it is on a subnet from which the upstream switch is reachable. The advantages of the overlay model include keeping the AP code and configuration simple; allowing a wireless network to be deployed over an arbitrary access network connecting the AP to the upstream switch (since client traffic is tunneled, it does not see the access network, so stations on the AP can be on completely different LANs than those available to the AP); and switches can form tunnels between themselves and send client traffic in those tunnels to further extend the choice of VLANs any given client on any AP may join. However, the overlay network suffers from the following: all traffic must pass through the upstream switch, which might be very far from the AP; complications involving MTU and other middle box issues when tunneling traffic; and not taking advantage of the distributed forwarding computational power available at the APs (in general, designs that push forwarding issues to the edge scale better).

The network **102** may include an Internet protocol (IP) network. In an embodiment, the network **102** is a wired backbone to which the wireless switch **104** is coupled. However, the network **102** may alternatively represent the network, or any other network, to which a backbone network is coupled or which acts as an alternative to a backbone network. Thus, the network **102** could include, for example, the Internet.

The wireless switch **104** is typically wire connected to the APs **106**. Thus, the "wireless" switch could be thought of, depending upon the implementation, as a switch for wireless traffic to and/or from a wired network. The wireless switch **104** is not necessarily wirelessly connected to anything. Each of the APs **106** could be wire coupled to respective switches such that each switch is wire coupled to only a single AP. So, although the one or more APs **106** is depicted as a plurality in the example of FIG. **1**, it should be understood that the number of APs per switch is implementation- and/or embodiment-specific. An AP and the wireless switch **104** could be combined into a single device. However, in this description, the functionality of an AP is differentiated from the functionality of a switch by acting as if the APs and the wireless switches are distinct devices.

The wireless switch **104** may or may not have all of the tools to manage wireless stations and the UAP mesh locally. For example, there may be additional management (e.g., AAA servers) further upstream from the wireless switch **104**. Since it is not critical where these services take place beyond the wireless switch **104**, for illustrative, simplicity, it is assumed that the wireless switch **104** handles all of these functions, either locally or by utilizing upstream components. For this reasons, the figures (other than FIG. **1**) do not depict components further upstream from the wireless switch **104**.

Wireless data may include, by way of example but not limitation, station association data and RF environment data. The station and RF data is used by the wireless switches **104** to support features including, by way of example but not limitation, roaming, auto channel selection, rogue AP detection, intrusion detection and the launching of countermeasures. The wireless switch **104** may share wireless data with other wireless switches (not shown).

The wireless switch **104** controls the APs **106** (and the APs in the UAP mesh **108**). In an embodiment, the APs **106** include radio transmitters and receivers (e.g., transceivers) that are used to provide wireless network connectivity for users and station access to the functions of the wireless switch **104**. Within an IEEE 802.11 context, a station is any IEEE 802.11 entity or the equivalent in other related standards, and it may be roaming or stationary. It should be noted that this definition may include APs.

In the example of FIG. **1**, each of the APs **106** anchors at least a portion of the UAP mesh **108** to the wired network. The APs **106** may be treated as border devices between the wireless switch **104** (or other upstream components of the system **100**) and the UAP mesh **108**. This enables more efficient use of wireless resources because proxy address resolution protocol (proxy ARP) may be used to enable the APs **106** to answer ARP requests on behalf of a remote device (e.g., a UAP for which an AP serves as an anchor to the wireless switch **104**).

In a non-limiting 802.11 implementation, each of the APs **106** supports switching packets from a radio interface to a wired interface as a standard 802.3 frame. The AP switching path may or may not support 802.1q tagged packets and may or may not support MAC or user-based ACLs. (Port, VLAN, or VPORT based ACLs may or may not be required.) It may be desirable for an AP to support local switching and overlay simultaneously. However, even if it does, it is not a requirement that packets should be switched locally and in overlay mode simultaneously. For example, a given VLAN on an AP may be switched either locally or in overlay mode.

In the example of FIG. **1**, the UAP mesh **108** is intended to depict a plurality of potentially discrete APs that do not have a wired connection to the wireless switch **104** or to the APs **106**. That is why the APs in the wireless mesh are referred to as "untethered." Any station in the UAP mesh **108**, whether a UAP or some other wireless station, is anchored to the wireless switch **104** by the AP **106** and zero or more UAPs that make up a chain of nodes from the station to the AP **106**. An AP that is closer to the wireless switch **104** in the chain may be referred to as anchoring downstream stations. For any given station, the path from the station to the wireless switch **104** may be referred to as a spanning tree because the UAP mesh **108** should not allow loops for traffic passing between a station and the wireless switch **104**.

When a UAP in the UAP mesh **108** is brought online, it will attempt to reach the wireless switch **104** through a path that is optimal. (Note: Although an optimal path is desired, it may or may not be accomplished in practice, depending upon the implemented algorithm and/or environmental factors). There are multiple metrics for measuring the distance of a UAP from one of the APs **106**. For example, the metric may be time. That is, the amount of time it takes for a packet to travel between the UAP and the AP anchoring the UAP. Although such a metric may work fine, it will typically vary depending upon environmental factors, such as traffic congestion or degraded received signal strength. For simplicity, the metric used herein is the number of hops between the UAP and the anchoring AP (AAP), with the understanding that this is but one of many potential metrics. Thus, if a UAP is one hop away from the AAP, the UAP may be referred to as a one-hop UAP. In general, a UAP may be referred to, as an N-hop UAP where the UAP is N hops from the AAP.

Advantageously, UAPs of the UAP mesh **108** may include an AP-local switching engine embodied in a computer-readable medium. An AP-local switching engine may make use of a station switching record (SSR) to determine how to switch a given message unit (e.g., a packet, frame, datagram,

etc.). This enables at least some traffic to be efficiently switched within the UAP mesh **108**. Moreover, advantageously, some traffic may be tunneled back to a switch, while other traffic is locally switched. Which traffic is tunneled back, and which traffic is locally switched, is an implementation-specific decision that becomes available by using the teachings described herein.

The SSR may include any information available at an upstream switch. In a non-limiting embodiment, the data available to the switch following station association and authentication includes station MAC, VLAN number, VLAN name, a local switch flag, a tagging flag, radio port, radio tag (used to map the radio port to the VLAN), ACLs (e.g., ingress and egress ACLs to be mapped to the station MAC), and/or a proxy-ARP flag. (Note: the proxy-ARP might only be honored if local switching is enabled.) In an illustrative embodiment that enables local switching for a particular VLAN (other examples are described later with reference to FIGS. **3**A to **3**D), the local switch flag is set to TRUE if local switching is enabled for the AP and the AP is connected to the VLAN specified by VLAN name. The tagging flag is set to TRUE if the station's VLAN is reachable through a 0.1 q tag. When this flag is TRUE, the VLAN-number may be taken as the 0.1 q tag value. With this information, the AP can create a VLAN and add the specified radio ports and wired ports to the VLAN with the specified tag values. The AP then sends the packet of learning from its network port to potentially update any intermediate switches.

It will be appreciated in light of the description provided herein that although aspects of the claimed subject matter are described relative to IEEE 802.11 standards, and that certain embodiments have particular features that are implemented within the 802.11 context, the claimed subject matter itself is not limited to 802.11 networks and may generally be applied to any applicable wireless network; and to the extent that future technological enhancements might obscure the distinctions between wireless switches, APs, and/or stations, the claimed subject matter is understood to include components providing the features of such switches, APs, and stations independently of how they are packaged, combined, or labeled.

In an illustrative embodiment, the UAP mesh **108** is created from a spanning tree. Each station in the UAP mesh **108** attempts to reach the wireless switch **104** along an optimal path. Assuming the optimal path is measured in the number of hops to the wire, if a first station's traffic passes through a UAP and along a path from there to the wire, a second station's traffic that passes through the UAP will take the same path from there to the wire. Since all stations take the optimal path, the stations may be represented as edge nodes of a tree where the AP at the wire is the root node. Thus, the AP mesh acts as a spanning tree for each station. It may be noted that the spanning tree is greedy at each node, which naturally results in an efficient (perhaps even optimized) tree flow.

Reducing the amount of data that passes through a wireless node, such as a UAP, to a wired switch is advantageous at least in part because wireless resources are relatively scarce. There is less need to conserve wired resources. However, conservation of wired resources is nevertheless of value in many cases. Accordingly, the teachings described herein with reference to an AP may be applicable to a wired AP, such as the APs **106** (FIG. **1**) or to a wireless AP, such the UAPs of the UAP mesh **108** (FIG. **1**). For this reason, in subsequent figures, an AP may refer to a wired or wireless AP, unless specifically identified as a UAP, which is wireless by definition (i.e., a UAP is an "untethered" AP).

FIG. **2** depicts an example of a AP-local dynamic switching system **200**. The system **200** includes a wireless switch **202**, an AP **204** coupled to the switch **202**, and two stations **206-1** and **206-2** (referred to collectively as wireless stations **206**) wirelessly coupled to the AP **204**. In an illustrative embodiment, the switch **202** provides the AP **204** with data in the form of an SSR, which may include various data about the wireless stations **206** (or, more generally, about wireless stations coupled to the switch **202** through the AP **204**). The SSR may be any data structure that includes data sufficient to facilitate native switching at the AP **204** or switching at the wireless switch **202**. The AP **204** decides whether to natively switch using, by way of example but not limitation, SSID, the class of data associated with the message, a VLAN associated with the station sending the message, authentication data associated with the user of the station sending the message, or some other factor.

In an illustrative embodiment, the wireless switch **202** knows that the AP **204** is to perform local switching and to which VLANs (if applicable) the AP is connected. However, this is not an absolute requirement.

In an illustrative embodiment, the AP **204** is a layer 2 switch. In an illustrative embodiment, the AP **204** is coupled to the wireless switch **202** via a tunnel **208**. Thus, a message can be tunneled to the wireless switch **202** for layer 2 switching at the wireless switch **202**. It should be noted that it may be difficult to support multiple layer 3 protocols. So, by keeping the switching at layer 2, the system **200** need not have a specific layer 3 protocol (e.g., IP). Moreover, if you have a layer 3 backbone with policy in the routers, switching may defeat the policy. Advantageously, layer 2 switching at least reduces or eliminates these problems.

Since the AP **204** is a switching device, in an illustrative embodiment, the wireless switch **202** does not need to perform packet replication for multicast. Hence, a single multicast packet is transmitted from the wireless switch **202** to the AP **204** where it is replicated by the AP **204** as needed.

In the example of FIG. **2**, the station **206-2** sends messages **210**, **212** to the AP **204**. The AP **204** treats the messages differently according to data available to the AP **204**. In the example of FIG. **2**, the AP **204** sends the message **210** to the switch **202** via the tunnel **208**. In the example of FIG. **2**, the AP **204** performs AP-local switching on the message **212** and sends the message **212** to the station **206-1**. It should be noted that the message **210** could be switched at the switch **202** and sent to the station **206-1**. Some examples of the various factors that could be considered when the AP **204** determines whether to switch locally or at the switch **202** (e.g., by tunneling) are explored by way of example but not limitation in the FIGS. **3**A to **3**D.

FIG. **3**A depicts an example of a system **300**A performing AP-local dynamic switching per SSID. The system **300**A includes an AP **302** and stations **304-1** to **304-3** (referred to collectively as the stations **304**). For illustrative purposes only, the AP **302** includes two virtual APs (VAPs) **306-1** and **306-2** (referred to collectively as VAPs **306**). As one of skill in the relevant arts would know, an AP can broadcast or otherwise handle multiple SSIDs. If the AP broadcasts or otherwise handles more than one SSID, the AP may be logically treated as multiple APs; each of the logical APs, associated with respective SSIDs, may be referred to as a VAP. In the example of FIG. **3**A, the AP **302** switches traffic through VAP **306-1** locally, if possible, and passes traffic through VAP **306-2** upstream for upstream switching. It may be noted that, in a non-limiting embodiment, the AP **302**

may perform AP-local dynamic switching per SSID, even if the AP **302** handles a single SSID; the determination is still dynamic even if only one outcome is possible.

FIG. **3**B depicts an example of a system **300**B performing AP-local dynamic switching per VLAN. The system **300**B includes an AP **312** and stations **314-1** to **314-3** (referred to collectively as the stations **314**). The stations are divided into VLANs **316-1** and **316-2** (referred to collectively as the VLANs **316**). For illustrative purposes only, the stations **314-1** and **314-2** are part of the VLAN **316-1** and the station **314-3** is part of the VLAN **316-2**. In the example of FIG. **3**B, the AP **312** switches traffic from VLAN **316-1** locally, if possible, and passes traffic from VLAN **316-2** upstream for upstream switching.

FIG. **3**C depicts an example of a system **300**C performing AP-local dynamic switching per class. The system **300**C includes an AP **322** and stations **324-1** to **324-2** (referred to collectively as the stations **324**). For illustrative purposes only, the station **324-1** sends data traffic **326** and voice traffic **328** to the station **324-2**. In the example of FIG. **3**C, the AP **322** switches voice traffic **328** locally, if possible, and passes data traffic **326** upstream for upstream switching. Advantageously, this may enable faster transmission times for voice traffic, which tends to be more time-sensitive than data traffic, while maintaining centralized control of data traffic.

FIG. **3**D depicts an example of a system **300**D performing AP-local dynamic switching per user. The system **300**D includes an AP **332** and stations **334-1** to **334-2** (referred to collectively as the stations **334**). Each of the stations **334** has a respective associated user **336-1** to **336-3** (referred to collectively as the users **336**). The users **336** and an AAA engine **338** are depicted for illustrative purposes only, to represent AP-local dynamic switching based on user authentication (e.g., AAA-driven switching). In the example of FIG. **3**D, the AP **332** switches traffic from the station **334-1** locally, if possible, because the user **336-1** is allowed to do AP-local switching. However, the AP **332** passes traffic from the station **334-3** upstream for upstream switching because the user **336-3** is not allowed to do AP-local switching. Advantageously, this may enable faster transmission times for certain users, while maintaining centralized control of other users. By way of example but not limitation, the users allowed to do AP-local switching could be employees, while those not allowed to do AP-local switching could be guests. As another example, the users allowed to do AP-local switching could be employees of a first company, while those not allowed to do AP-local switching could be employees of a second company where the first company has superior (or at least different) access rights.

The examples of FIGS. **3**A to **3**D are intended to provide only a subset of the possible techniques for implementing AP-local dynamic switching. The techniques, whether illustrated in FIGS. **3**A to **3**D or not, could be used alone or in combination with other techniques, whether illustrated in FIGS. **3**A to **3**D or not.

FIG. **4** depicts an example of an AP **400** capable of AP-local dynamic switching. The AP **400** includes a processor **402**, an optional Ethernet interface **404**, a radio **406**, a dynamic switching module **408**, and a station switching record (SSR) database **410** coupled together via a bus **412**. It may be noted that the various components could be coupled via some means other than the bus **412** without deviating from the scope of the teachings provided herein. The Ethernet interface **404** is optional because, for example, the AP **400** does not use Ethernet, the AP is a UAP that does not have a wired interface, or for some other reason. The radio may be an 802.11 radio, or some other wireless radio.

In an illustrative embodiment, the dynamic switching module **408** is implemented in a computer-readable medium, such as non-volatile storage and/or memory. The SSR database **410** is also implemented in a computer-readable medium, such as non-volatile storage and/or memory. In operation, portions of the dynamic switching module **408** may be loaded from non-volatile storage into memory, and executed by the processor **402**. In an alternative embodiment, the dynamic switching module **408** may have a dedicated processor (not shown). Whether the processor is shared or dedicated, the dynamic switching module **408** and the processor may be referred to collectively as a dynamic switching engine.

In the example of FIG. **4**, in operation, the AP **400** receives from an upstream switch an SSR associated with a downstream station. The SSR is stored in the SSR database **410**. The downstream station may be operationally connected to the AP **400** through a wireless link, either directly or indirectly through intervening nodes of a wireless mesh. The dynamic switching engine uses the SSR to determine whether to perform AP-local switching for traffic received from the downstream station at the AP **400**, or to send the traffic upstream toward the upstream switch.

FIG. **5** depicts a flowchart **500** of an example of a method for AP-local dynamic switching. In the example of FIG. **5**, the flowchart **500** starts at optional module **502** where data associated with a wireless station is received. The data may be received at, for example, an AP. The module **502** is optional because instead (or in addition), it may be possible to use data associated with traffic to make determinations regarding whether to AP-locally switch the traffic, as is described shortly.

In the example of FIG. **5**, the flowchart **500** continues to module **504** where Layer 2 traffic is received from the wireless station. Advantageously, since the traffic is Layer 2, the system may operate using any Layer 3 protocols (e.g., IP), or even multiple Layer 3 protocols.

In the example of FIG. **5**, the flowchart **500** continues to decision point **506** where it is determined whether to Layer 2 switch the traffic locally. The determination as to whether to switch the traffic locally may be made using data associated with the wireless station (see, e.g., module **502**) or data associated with the traffic itself. For example, the wireless station may be authorized for AP-local switching because the wireless station is associated with a particular VLAN. As a second example, the traffic may have a relatively high priority, such as voice traffic often has. If the traffic has a relatively high priority, the determination may be made to switch locally to get the traffic to its destination more quickly. It may be noted that in the second example, the module **502** is optional.

In the example of FIG. **5**, if it is determined that the traffic is to be Layer 2 switched locally (**506**-Y), the flowchart. **500** continues to module **508** where the traffic is Layer 2 switched locally, and to module **510** where the traffic is sent toward its destination. Having switched and sent the traffic, the flowchart **500** ends.

In the example of FIG. **5**, if it is determined that the traffic is not to be Layer 2 switched locally (**506**-N), the flowchart **500** continues to module **512** where the traffic is Layer 2 tunneled upstream. Presumably, the traffic is switched further upstream. Having Layer 2 tunneled traffic upstream that is not to be switched locally, the flowchart **500** ends.

As used herein, an AP may refer to a standard (tethered) AP or to a UAP. Where a distinction should be drawn, an AP may be referred to as a "(tethered) AP" or a "UAP," as

appropriate. As used herein, the term "embodiment" means an embodiment that serves to illustrate by way of example but not limitation.

Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

The invention claimed is:

1. An apparatus, comprising:

a processor; and

a non-transitory memory in operable communication with the processor, the memory storing instructions executable by the processor to:

receive a signal representing a priority characteristic of a first virtual local area network (VLAN) associated with a first wireless station;

determine whether to AP-locally switch traffic from the first wireless station based on the priority characteristic, thereby determining a priority of the first VLAN as compared with a second VLAN;

when the priority characteristic is a first value, switch the traffic locally to the second wireless station by forwarding the traffic to the second wireless station without forwarding the traffic to an intervening wireless station; and

when the priority characteristic is a second value less than the first value, tunnel the traffic from the first wireless station upstream to the second wireless station.

2. The apparatus of claim **1**, wherein the instruction to determine whether to AP-locally switch traffic includes instructions to determine whether to AP-locally switch traffic based on a characteristic of a target of the traffic.

3. The apparatus of claim **1**, wherein the priority characteristic is associated with a sender of the traffic.

4. The apparatus of claim **1**, wherein the instruction to determine whether to AP-locally switch traffic includes instructions to determine whether to AP-locally switch traffic based on an identifier of the first VLAN associated with the first wireless station.

5. The apparatus of claim **1**, wherein the instruction to determine whether to AP-locally switch traffic includes instructions to determine whether to AP-locally switch traffic based on a service set identification (SSID) of the AP.

6. The apparatus of claim **1**, wherein the instruction to determine whether to AP-locally switch traffic includes instructions to determine whether to AP-locally switch traffic based on authentication data associated with a user of the first wireless station.

7. The apparatus of claim **1**, wherein the instruction to tunnel includes an instruction to tunnel the traffic via a Layer 2 tunnel.

8. An apparatus, comprising:

a processor; and

a non-transitory memory in operable communication with the processor, the memory storing instructions executable by the processor to:

receive data from a first wireless station and data from a second wireless station;

determine, at a first time, a first VLAN associated with the first wireless station;

at a second time after the first time, Layer-2 switch locally the data from the first wireless station, by sending the data to a further wireless station without sending the data to an intervening wireless station;

determine, at a third time, a second VLAN associated with the second wireless station; and

at a fourth time after the third time, Layer-2 tunnel the data from the second wireless station upstream to a wireless switch.

9. The apparatus of claim **8**, wherein the instructions further include instructions to determine, before the second time and after the first time, whether to AP-locally switch or to tunnel the data from the first wireless station, based on the first VLAN being associated with the first wireless station.

10. The apparatus of claim **8**, wherein the instructions further includes instructions to determine, before the second time and after the first time, whether to AP-locally switch or to tunnel the data from the first wireless station, based on an SSID of the first wireless station.

11. The apparatus of claim **8**, wherein the instructions further include an instruction to determine, before the second time and after the first time, whether to AP-locally switch or to tunnel the data from the first wireless station, based on authentication data associated with a user of the first wireless station.

12. The apparatus of claim **8**, wherein the instructions further include instructions to determine, before the second time and after the first time, whether to AP-locally switch or to tunnel the data from the first wireless station, based on an SSR associated with the first wireless station.

13. The apparatus of claim **8**, wherein the instructions further include instructions to determine, before the fourth time and after the third time, whether to AP-locally switch or to tunnel the data from the second wireless station, based on an identifier of the second VLAN.

14. The apparatus of claim **8**, wherein the instructions further include instructions to determine, before the fourth time, whether to AP-locally switch or to tunnel the data from the second wireless station, based on an SSID of the second wireless station.

15. The apparatus of claim **8**, wherein the instructions further include instructions to determine, before the fourth time, whether to AP-locally switch or to tunnel the data from the second wireless station, based on authentication data associated with a user of the second wireless station.

16. An apparatus, comprising:

a processor; and

a non-transitory memory in operable communication with the processor, the memory storing instructions executable by the processor to:

receive data from a wireless station, the data indicating a priority characteristic of a first VLAN associated with the wireless station;

receive traffic from the wireless station;

determine whether to AP-locally switch the traffic from the wireless station based on the priority characteristic, thereby determining a priority of the first VLAN as compared with a second VLAN;

when the priority characteristic is a first value, switch the traffic locally to a second wireless station by forwarding the traffic to the second wireless station without forwarding the traffic to an intervening wireless station; and

when the priority characteristic is a second value less than the first value, tunnel the traffic from the wireless station upstream to a second wireless station.

17. The apparatus of claim **16**, wherein the instruction to determine whether to AP-locally switch traffic include

instructions to determine whether to AP-locally switch traffic based on a station switching record (SSR) associated with the first wireless station.

18. The apparatus of claim **16**, wherein:

the instruction to determine whether to AP-locally switch traffic include instructions to determine whether to AP-locally switch traffic based on a station switching record (SSR) that is associated with the first wireless station and that includes data selected from at least one of a station media access control (MAC), a SSID, a VLAN name, an authentication, authorization and accounting (AAA) data, or user data.

19. The apparatus of claim **16**, wherein the instruction to determine whether to AP-locally switch traffic include instructions to determine whether to AP-locally switch traffic based on a class of the data.

20. The apparatus of claim **16**, wherein the instructions further include instructions to determine, before the fourth time, whether to AP-locally switch or to tunnel the data from the second wireless station, based on an SSR associated with the second wireless station.

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